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## Joint Section 1

Joint Section 1 is the portion of copper tubing that was soldered to the female brass valve fitting. A stereomicroscope image of Joint Section 1 is shown in Figure 9. The prominent feature on this section of copper tubing is the ridge that circumnavigates the tube. This ridge is shown at a higher magnification in the SEM image in Figure 10. EDS analysis was performed in the regions denoted by the red boxes labeled "1" and "2" in this image. The spectra acquired from this analysis are shown in Figure 11 and Figure 12. The likely source of the carbon peaks in these spectra is soot or other carbonaceous material deposited during or after the fire. The source of the oxygen peaks is likely metal oxides. The primary metallic elements present in these regions are tin and copper, which indicates that this ridge is composed of solder.

The conversations with the plumber who initially installed this pipe indicated that he typically used Canfield "100% Watersafe" or similar brand solder. According to the manufacturer's MSDS, the composition of this solder is 95% tin, 4% copper and 1% silver, by weight. While both tin and copper are present in the spectra in Figure 11 and Figure 12, silver is not detected. Unfortunately, the most intense silver peak has an energy of 2.98 eV, which overlaps with one of the low intensity tin peaks. The approximate location of the silver peak is indicated in both spectra. As a result of this peak overlap, and the relatively small amount of silver in this alloy, EDS cannot confirm the presence of silver in this solder. The presence of the lead peak in Figure 12 is interesting because "100% Watersafe" and other plumbing solders are lead-free alloys; therefore, the lead must come from another source.

This section of copper tubing was cut parallel to the axis of the tube and metallographically prepared so that the cross-section of the copper/solder interface could be investigated. A stereomicroscope image of this cross-section is shown in Figure 13. The ridge of solder can be clearly seen on both sides of the cross-section. This ridge is shown at a higher magnification in Figure 14. It is very interesting to note that the ridge of solder appears to have retained its original shape and still comes to a rather sharp point. The shape of this solder ridge indicates that the solder was not molten when joint was separated. If this ridge of solder had melted, then surface tension would have caused the ridge to lose its original shape in order to reduce its surface area.

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A layer of solder is present on the right of the solder ridges shown in Figure 14. This layer of solder would have been present between the brass valve fitting and the copper tube prior to their separation. The photomicrographs in Figure 15 show this layer of solder at a higher magnification. From these photomicrographs it can be seen that the solder remaining on the surface of the copper is approximately 200  $\mu\text{m}$  thick.



Figure 9. Stereomicroscope image of Joint Section 1.

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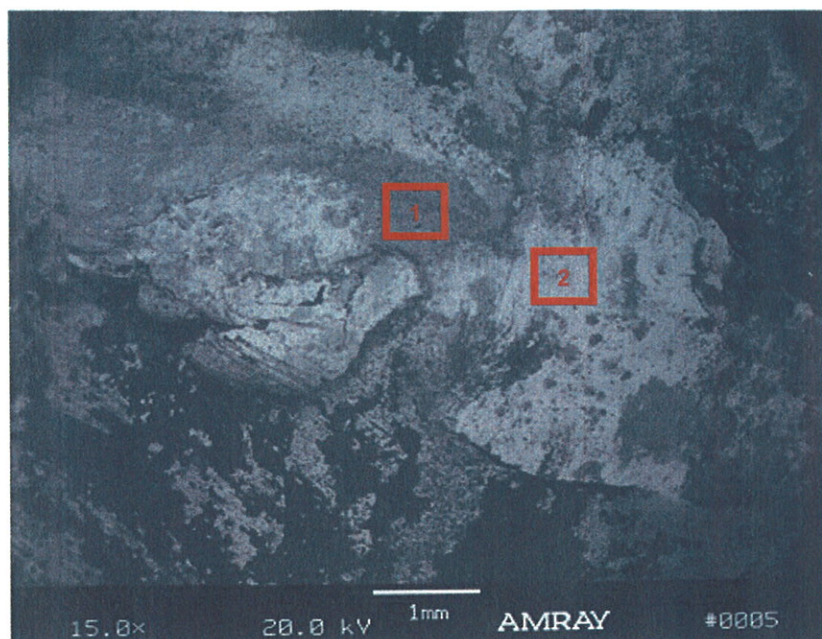


Figure 10. Backscattered SEM image of the ridge on Joint Section 1. EDS spectra acquired from the regions in the red boxes are shown in Figure 11 and Figure 12.

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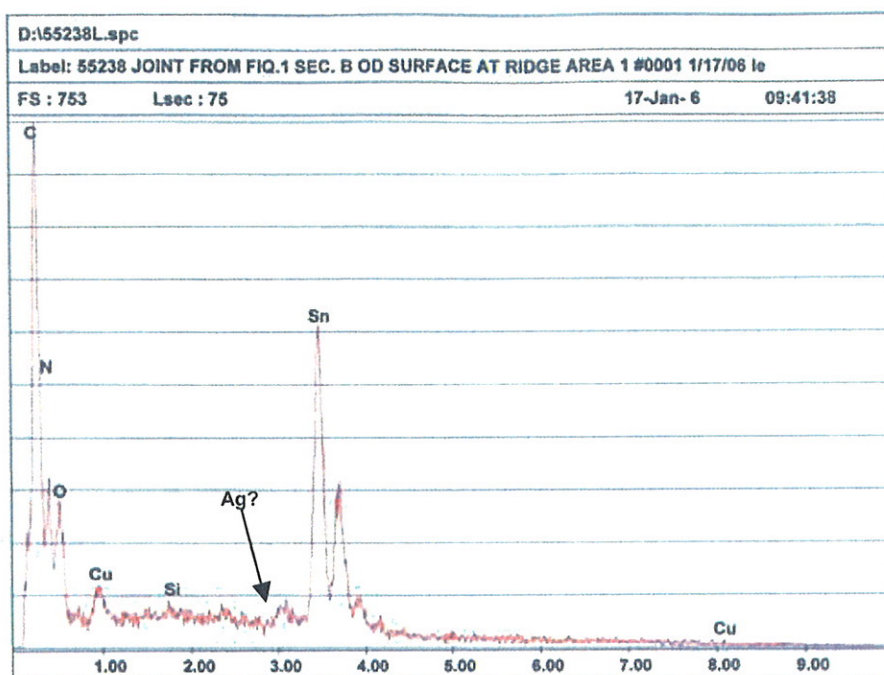


Figure 11. EDS spectra of the region inside red box #1 shown in Figure 10.

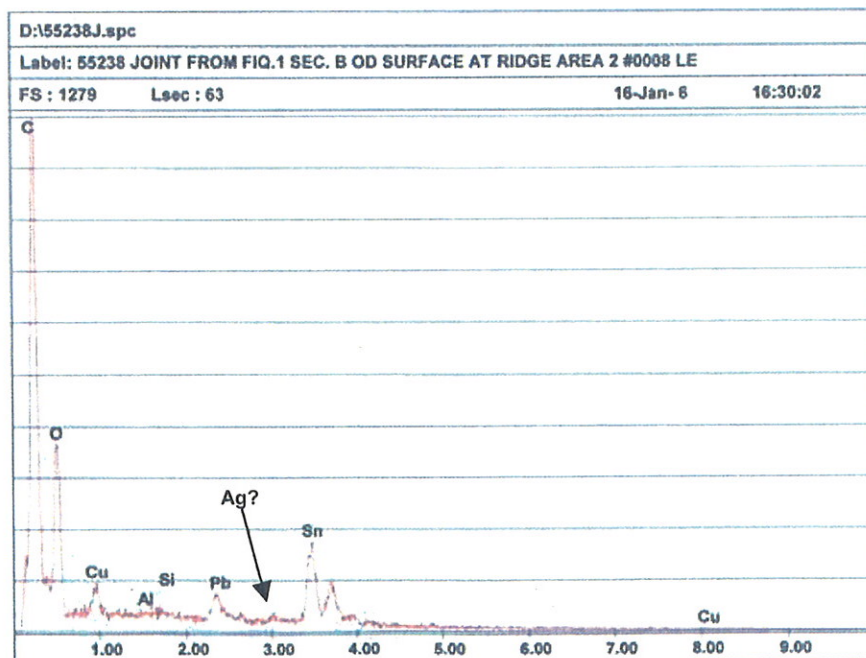


Figure 12. EDS spectra of the region inside red box #2 shown in Figure 10.



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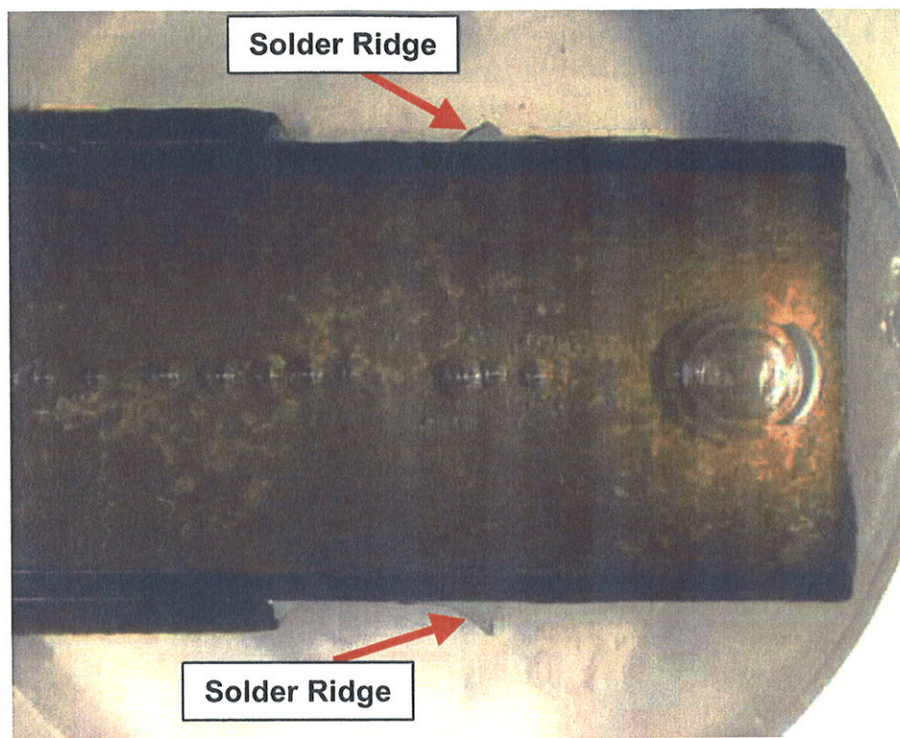


Figure 13. Stereomicroscope image of the polished cross-section of Joint Section 1.